Overview of Performance Assessment for the Waste Isolation Pilot Plant

DOE/EPA Meeting on Changes from the CCA to the CRA

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Performance Assessment

- **Performance Assessment provides a quantitative estimate of the future performance of a system.**
- **PA answers four questions about a repository system:**
  1. **What can happen at a repository after permanent closure?**
  2. **How likely is it to happen?**
  3. **What can result if it does happen?**
  4. **What level of confidence can be placed on the estimate?**

Containment Requirements

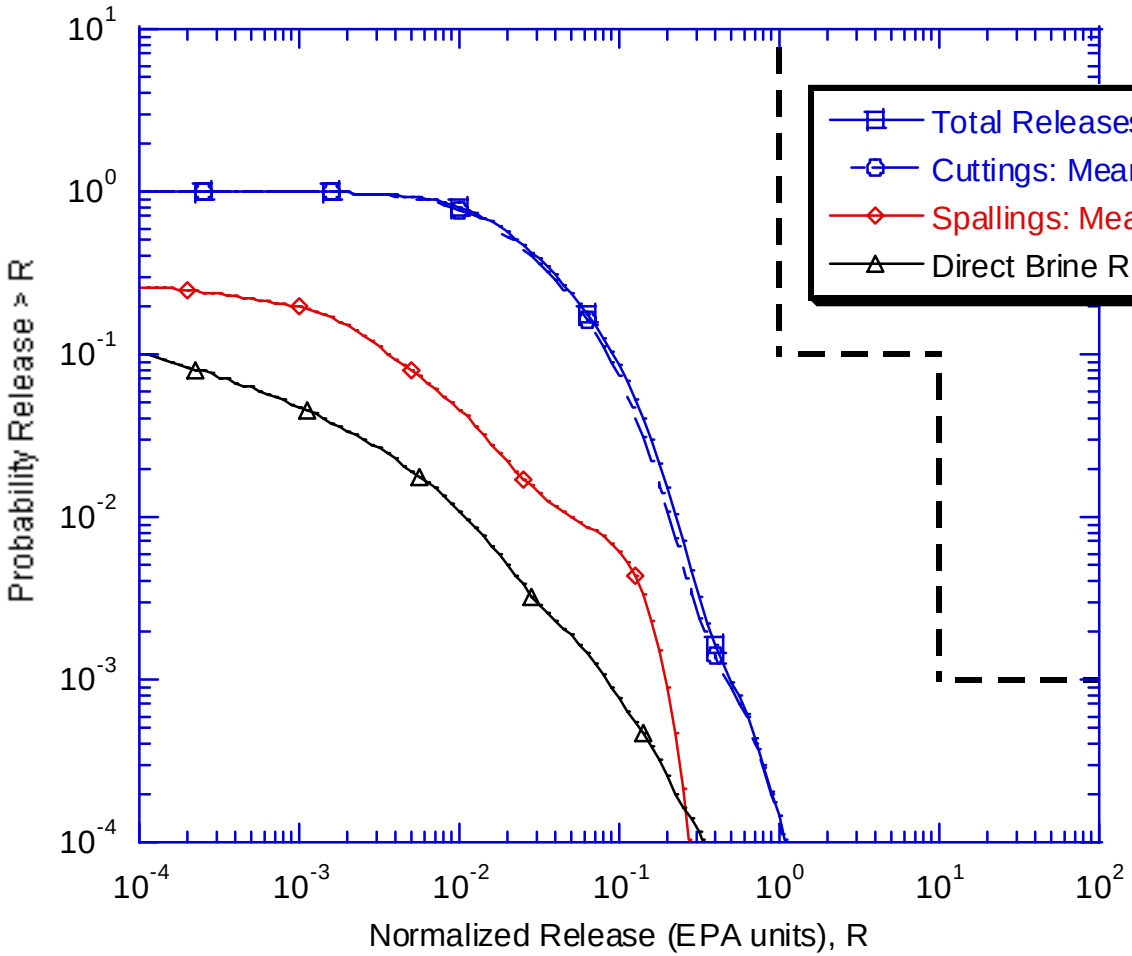
40 CFR 191.13

(a) Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation, based upon performance assessments, that the cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal from all significant processes and events that may affect the disposal system shall:

(1) Have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Table 1 (Appendix A); and

(2) Have a likelihood of less than one chance in 1,000 of exceeding ten times the quantities calculated according to Table 1 (Appendix A).

CCDF is a Measure of Compliance



Less than 1 chance in 10 of exceeding 1 EPA unit

Less than 1 chance in 1000 of exceeding 10 EPA units

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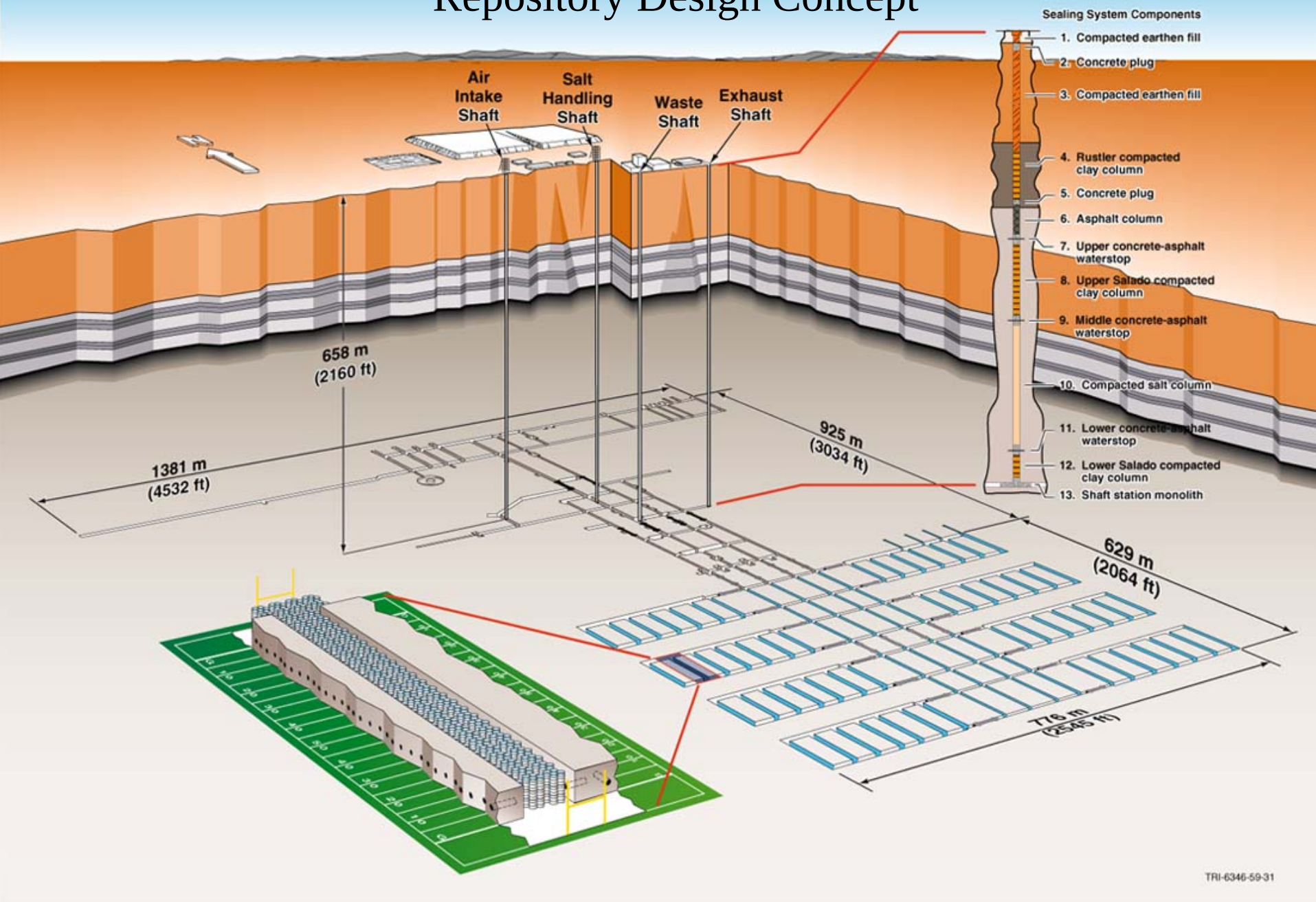
Repository Design Concept



Performance Assessment Methodology

- Features, Events, and Processes (FEPs)
- Conceptual Model Development and Review
- Process Models
- Scenario Development
- Release Mechanisms
- Treatment of Uncertainty

Features, Events, and Processes

Question: What needs to be considered and included in PA?

Answer: Features, events, and processes (FEPs)

FEPs are screened according to:

- **Probability:** If a FEP has a probability of occurring less than 10^{-4} in 10,000 years it does not have to be included in PA (e.g., meteorite impact)
- **Consequence:** if a FEP is beneficial to performance or is not relevant to WIPP it does not have to be included in PA (e.g., sorption, lakes, oceans, tides, floods).
- **Regulation:** Certain FEPs are either screened in or out by regulation (e.g., mining, resource extraction following drilling).

Types of Models

- Conceptual Models
  - Set of qualitative assumptions used to describe a system or subsystem for a given purpose
- Mathematical Models
  - Predictive mathematical description of conceptual models
- Numerical Models
  - Implementation of mathematical models in computer software applications.
  - Developed to provide approximations of mathematical model solutions because most mathematical models do not have closed-form solutions
- Process Models
  - General term for the implementation of sub models. Includes both numerical models or parts of numerical models.

24 WIPP Conceptual Models

- *Disposal system geometry*
- Culebra hydrogeology
- *Repository fluid flow*
- Salado
- Impure halite
- Salado interbeds
- *Disturbed rock zone*
- Actinide transport in Salado
- Units above the Salado
- Dissolved transport in Culebra
- Colloidal transport in Culebra
- Exploration boreholes
- Cuttings/Cavings
- *Spallings*
- Direct brine release
- Castile and brine reservoir
- Multiple intrusions
- Climate change
- Creep closure
- Shafts and shaft seals
- Gas generation
- Chemical conditions
- Dissolved actinide source term
- Colloidal actinide source term

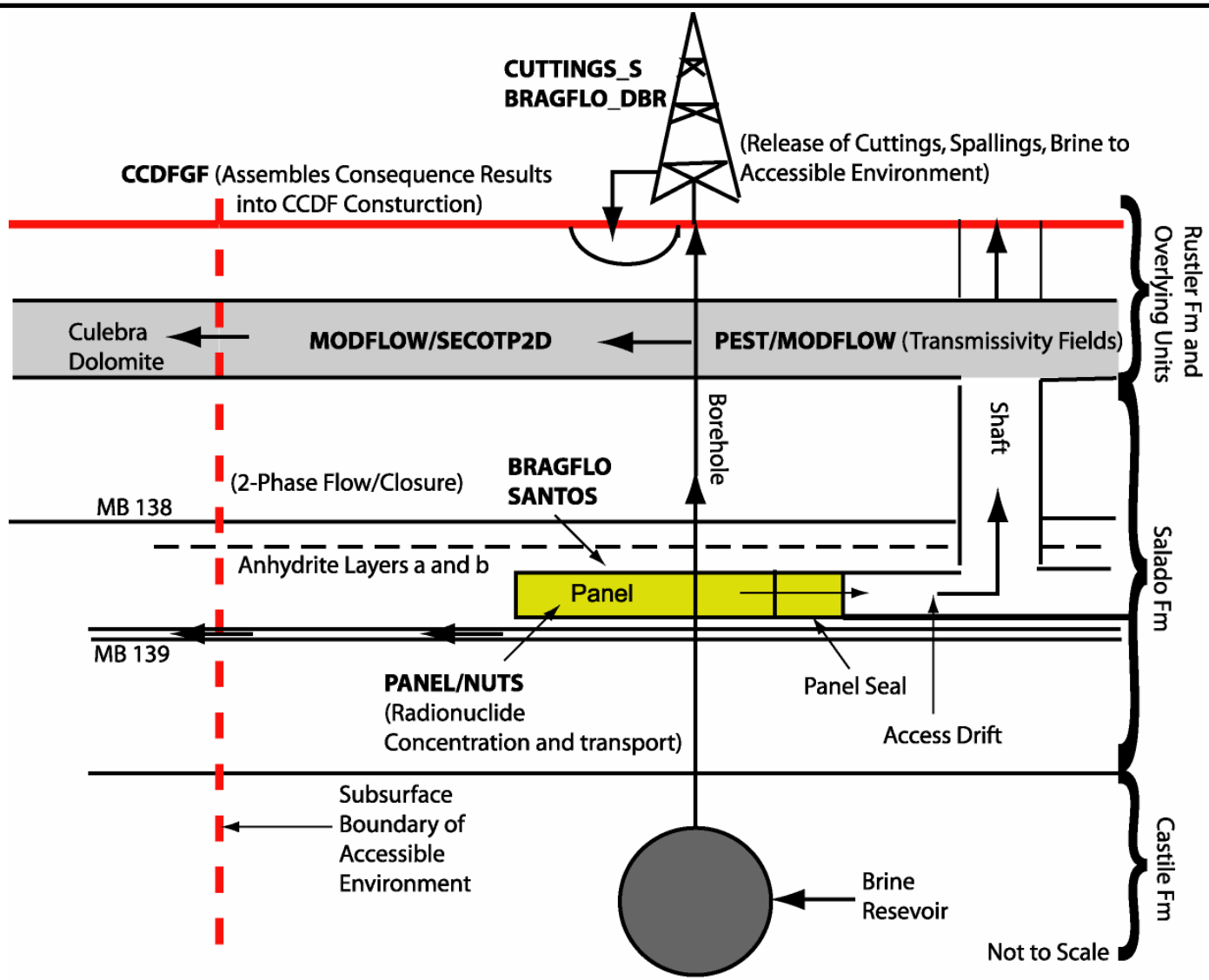
Changed in Salado Flow Peer Review
Changed in Spallings Peer Review

Implementation of other conceptual models have changed for the CRA

Scenario Development

- All retained FEPs must be accounted for in PA in at least one scenario.
- FEPs can be included by explicit modeling or by parameter assignment.
- Expected FEPs are included in all scenarios
  - Creep closure
  - Brine flow, gas generation
- Disruptive FEPs are included in disturbed scenarios.
  - Drilling, mining, brine pocket

Release Pathways



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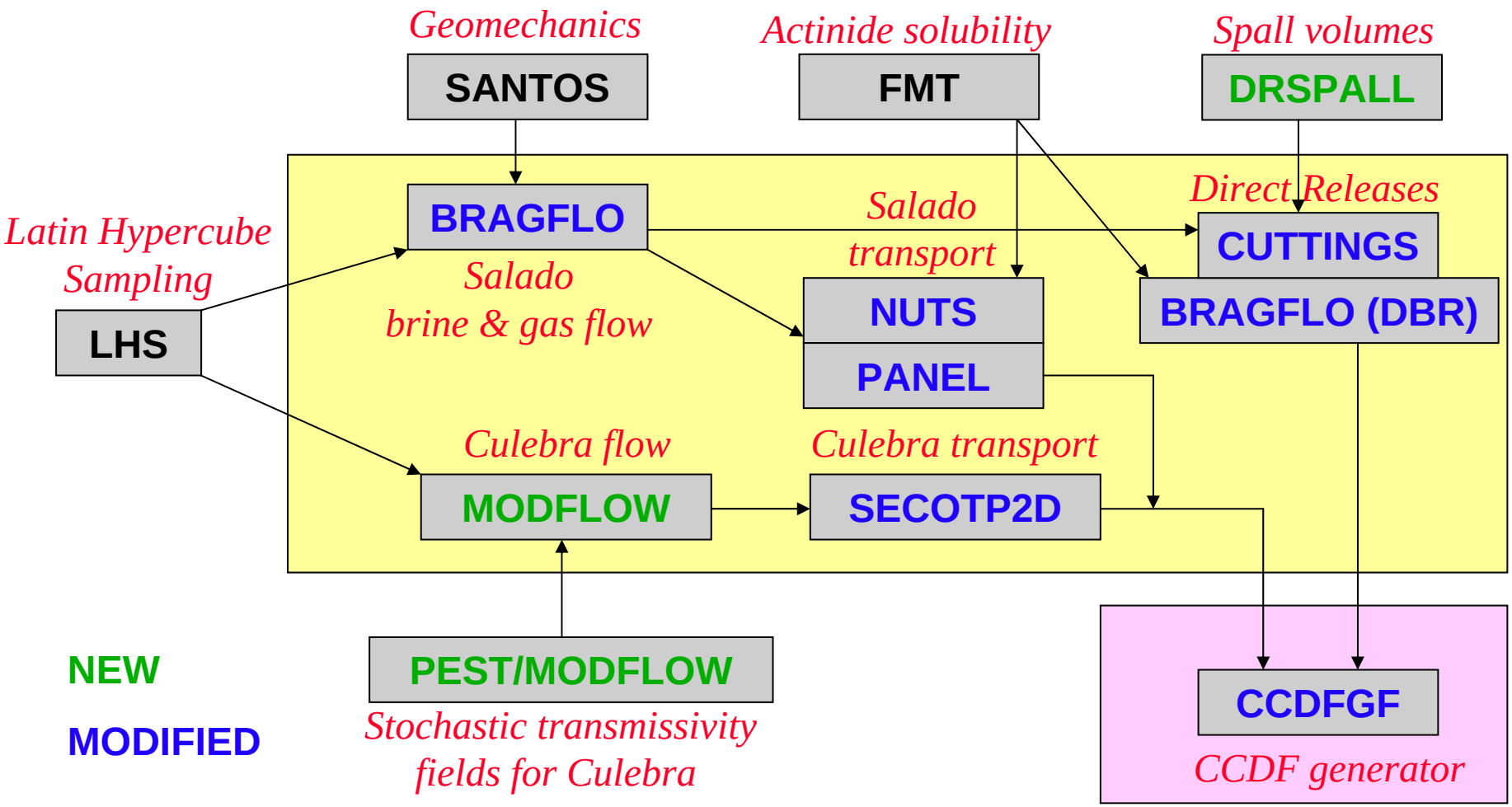
Release Mechanisms

- **Direct Releases (occur during or immediately after drilling)**
  - **Cuttings (Solids from drilling)**
  - **Cavings (Solids from drilling)**
  - **Spallings (Solids from pressure release)**
  - **Direct Brine Release (Brine from pressure release)**
- **Long-term Releases**
  - **Groundwater Transport in Culebra**
  - **Groundwater Transport in Salado**

Major PA Codes in the CRA



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Subjective Uncertainty

1. **Subjective Uncertainty (epistemic)**
   - **Arises from a lack of knowledge about the repository system. Examples: permeability, porosity, zero-reaction**

   - **WIPP PA treats subjective uncertainty in several ways:**
     i. **Make conservative assumptions. Example: Waste characteristics**
     ii. **Sample certain parameter values from probability distributions that cover the range of uncertainty.**

Dealing with Subjective Uncertainty

- Latin Hypercube sampling (LHS) is used to define 100 sets of uncertain parameters.
- One realization of the sampled parameters is called a "vector".
- The group of 100 vectors is called a "replicate".
- The replicate essentially covers the full range of all the uncertain parameter distributions.
- Typically three replicates are run to demonstrate statistical equivalence.

Stochastic Uncertainty

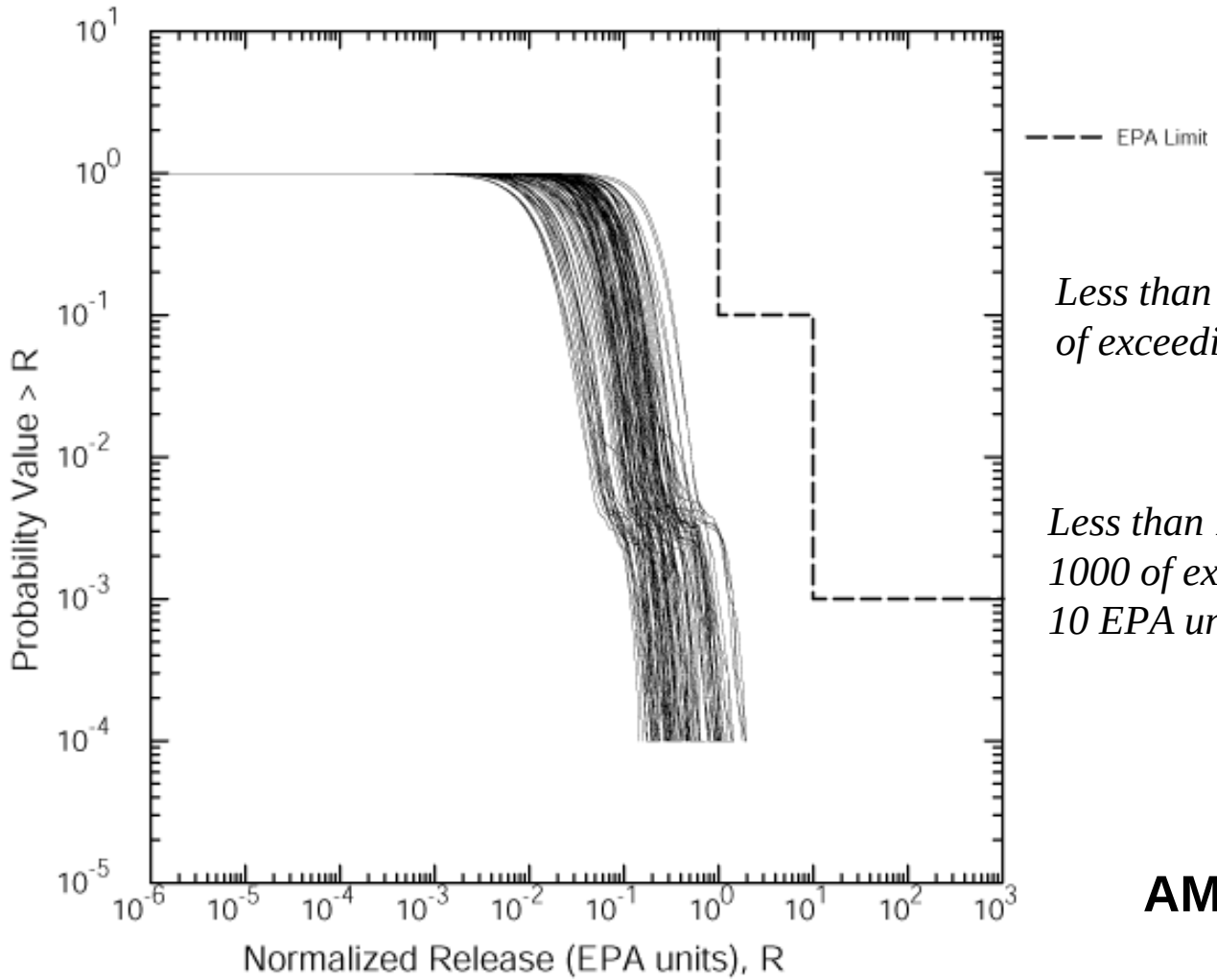
2. Stochastic Uncertainty (aleatory)

- **Arises because the system can potentially behave in many different ways. The sequence of future events *cannot* be known.**
  - **Examples: Timing and location of future drilling events, when potash mining is completed**
  - **WIPP PA treats stochastic uncertainty through Monte Carlo sampling on possible futures (sequences of events).**

Construction of the CCDF

- For each of 100 vectors, 10,000 possible futures are assembled.
  - A future consists of one possible sequence of drilling intrusions and mining activity over 10,000 years.
- For each future, total releases are calculated by linking together process model results from appropriate scenarios.
- A single CCDF shows releases for 10,000 possible futures for a given vector.
- A collection of 100 CCDFs represents the full range of uncertainty.

CCDF is a Measure of Compliance



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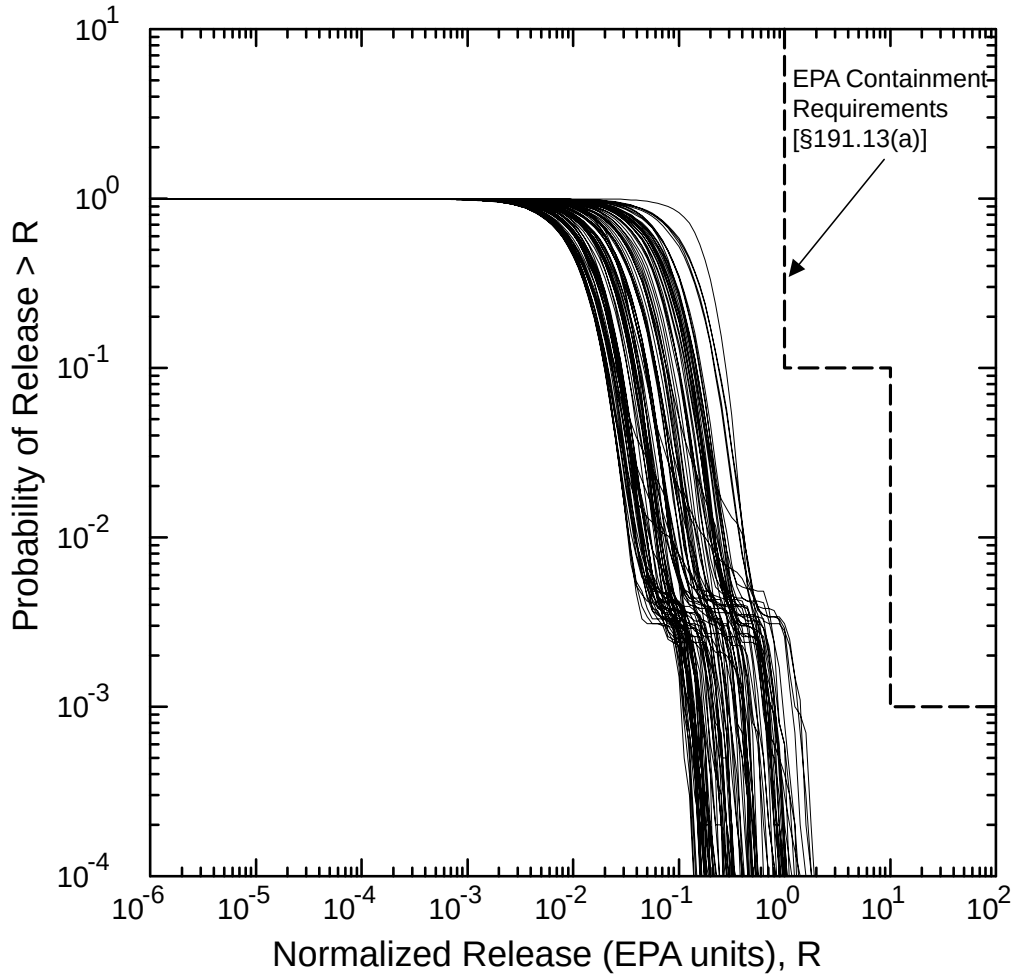

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Summary

- **Four Conceptual Models were changed between the CCA and first CRA.**
  - **Changes were driven by Option D panel closures and a new Spallings model.**
- **Other changes to codes, parameters, and model inputs were also made for the CRA.**
- **All changes are documented in the CRA, primarily in Chapter 6 and Appendix PA.**